


Delayed Presentation of Unstable Triangular Fibrocartilage Complex Tears Treated with Volar Foveal Ligament Repair

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J Wrist Surg 2021;10:144–149.

Abstract

Hypothesis An open volar surgical approach with suture anchor repair of the foveal ligament and temporary pinning of the distal radioulnar joint (DRUJ) is an effective way to treat DRUJ instability associated with chronic foveal tears of the triangular fibrocartilage complex (TFCC).

Methods We retrospectively reviewed nine patients with foveal ligament tears of the TFCC and DRUJ instability who underwent open repair of the TFCC using a volar surgical approach, combined with temporary pinning of the DRUJ for 8 weeks. Pain, instability, arc of motion, and functional outcomes scores were evaluated.

Results Mean patient age was 40.5 years (range 16.3–56.2). Average time from injury to surgery was 8.4 months (range 2.9–23.3 months). Average final follow-up was 18.9 months from injury (range 12.0–29.3 months), 10.5 months from surgery (range 3.9–18.6 months), and 8.7 months from pin removal (range 1.7–17.2 months). At final follow-up, all patients demonstrated clinically stable DRUJ. Pain scores diminished significantly from pre to final postoperative visits, with averages of 6.8 (range 4.0–9.0) improving to a mean of 0.70 (range 0.0–2.0), respectively. Average postoperative forearm rotation was 71.1 degrees in supination and 76.1 degrees in pronation (average total arc of motion 147.2 degrees, range 90–160 degrees). Average postoperative wrist motion was 68.8 degrees in flexion and 70.6 degrees in extension (average total arc of motion 139.4 degrees, range 110–160 degrees). No patients developed crepitus, recurrent DRUJ instability, or required revision surgery (subsequent to pin removal).

Conclusion Volar suture anchor repair of the foveal ligament of the TFCC with DRUJ pinning led to reliable outcomes within this patient group including a stable DRUJ with improved functional outcomes regarding pain, stability, and range of motion in patients with foveal TFCC tears and associated DRUJ instability. These results compare favorably with dorsal repair of the foveal ligament.

Level of Incidence This is a Level IV, therapeutic study.

Keywords

- foveal ligament
- TFCC
- volar approach
- DRUJ instability

The triangular fibrocartilage complex (TFCC) is an intrinsic stabilizer of the distal radioulnar joint (DRUJ) and plays an important role in wrist movement, forearm rotation, and grip strength.^{1–6} The anatomy of the TFCC is primarily

composed of the articular disk, dorsal and palmar radioulnar ligaments, extensor carpi ulnaris (ECU) tendon subsheath, the ulnocarpal ligaments,⁶ and the critically important foveal ligament insertion to the distal ulna (►Fig. 1A). The

received

August 31, 2020

accepted after revision

October 19, 2020

published online

January 3, 2021

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Thieme Medical Publishers, Inc.,

333 Seventh Avenue, 18th Floor,

New York, NY 10001, USA

DOI [https://doi.org/](https://doi.org/10.1055/s-0040-1721410)

10.1055/s-0040-1721410.

ISSN 2163-3916.



Fig. 1 Normal foveal insertion of the triangular fibrocartilage complex (TFCC) on T1 magnetic resonance imaging (MRI) (A) contrasted with foveal ligament tear of the TFCC on T2 MRI (B, C), and foveal ligament tear of the TFCC on T1 MRI (D).

triangular fibrocartilage and its supporting ligaments form a three-walled structure to support the ulnar carpus and provide stability of the DRUJ.^{6,7} A foveal ligament tear of the TFCC (a tear of the TFCC insertion to the ulna) often leads to DRUJ instability.^{2,6–11}

Foveal ligament tears with associated DRUJ instability can produce significant disability, including ulnar-sided wrist pain, subluxation, mechanical symptoms, weakness, and restricted range of motion.⁶ Common mechanisms of injury to the TFCC include an axial load with the wrist extended and pronated, excess torque from wrist and forearm rotation often seen in racket sports and golfers, or excessive traction injury from wrist hyperextension and radial deviation.^{5,6,12} Various open, minimally open, and arthroscopic surgical techniques have been described for the repair of TFCC foveal tears with associated DRUJ instability, but there is no consensus for the ideal approach.¹³

Recent literature suggests that arthroscopic debridement with or without suture anchor as a sole treatment for foveal ligament tears has become increasingly popular among hand surgeons, with satisfactory functional outcomes. However, this method may be associated with increased complications and surgical revision rates as high as 17%.^{14,15} While peripheral TFCC tears can be adequately treated with arthroscopy, in senior author's (S.D.D.) experience it is difficult to repair foveal ligament tears with this approach because the arthroscopic approach does not consistently allow for adequate visualization of the repair. Furthermore, driving the suture anchor percutaneously through the TFCC and then into the bone may cause iatrogenic damage to the TFCC.

Historically, surgical repairs of foveal TFCC tears have been performed using a dorsal approach with acceptable clinical outcomes,^{7,12,16–18} but the literature has suggested the potential for better functional outcomes via a volar approach as was previously described by Moritomo.^{12,19–21} During a dorsal approach to the TFCC, the foveal lesion is challenging to visualize because of the ECU tendon subsheath. The strong but thin dorsal superficial limb of the radioulnar ligament is also problematic as it does not have great structural integrity after surgical division (for exposure of the foveal) and subsequent repair, potentially worsening the DRUJ instability.¹² While the deep dorsal limb prevents volar ulnar translation, the interosseous membrane also prevents volar ulnar translation when the deep dorsal limb is cut.^{3,19} Therefore,

the volar approach to the TFCC allows for excellent visualization and repair of the TFCC foveal tear and deep volar limb, while avoiding iatrogenic damage to the superficial and deep dorsal limbs as well as the ECU sheath floor.

We hypothesize that open repair of the TFCC using a previously described volar approach augmented with pinning of the DRUJ will lead to satisfactory functional outcomes in patients with delayed presentation foveal ligament tears of the TFCC with associated DRUJ instability. Pinning was utilized to eliminate forearm rotation and protect the foveal ligament repair. Chronic cases inherently pose a challenge due to the fact that increased time from injury leads to progressive scarring, degeneration, and shortening of the foveal ligament. However, in our experience, as long as there is evidence of a remnant of the foveal ligament on preoperative MRI, we are able to capture enough tissue in a stitch using a suture anchor to complete the repair. We compare our outcomes to previously-published retrospectively gathered cohorts with primary dorsal repairs and also those with tendon reconstructions of the unstable DRUJ.^{12,16,22}

Materials and Methods

Study Design and Patient Selection

We retrospectively reviewed nine consecutive patients with foveal ligament tears of the TFCC and chronic DRUJ instability, who underwent open repair of the TFCC using a previously described volar surgical approach and pinning of the DRUJ for 8 weeks. All surgeries were performed by the senior author at a tertiary care medical center. We performed chart reviews to obtain preoperative history and physical examination details including age, sex, smoking status, workers compensation (if eligible), and mechanism of injury. Time intervals between injury and surgery, surgery and pin removal, and the total time from first visit to final follow-up were calculated. Pre- and postoperative pain scores, arc of motion (measured via goniometer by the treating physician), disability of the arm, shoulder, and hand (quickDASH) scores, and DRUJ piano key stability testing results were obtained. Institutional Review Board approval was obtained for this study.

Our inclusion criteria consisted of patients with chronic ulnar-sided wrist pain, TFCC tears with complete tears of the

foveal ligament, and DRUJ instability diagnosed clinically on the treating surgeon's physical exam. The diagnosis was made clinically by the treating physician and confirmed with MRI of the wrist, which demonstrated a foveal tear of the TFCC (►Fig. 1). Patients with acute injuries (treatment within 6 weeks) were excluded. Patients with significant preoperative ulnar positive variance or ulnar impaction were also excluded. One patient had previously undergone an open dorsal surgical approach with soft tissue reconstruction by a different surgeon. Two patients were participants in worker's compensation (WC). Ultimately, nine patients with a mean age of 40.5 years at the time of surgery were included.

Surgical Technique

As previously stated, the foveal ligament tear is visualized on MRI preoperatively. If residual foveal ligament is present on MRI, then the surgeon proceeds with the intention of repairing the foveal ligament. The procedures are performed under regional anesthesia under tourniquet control. A radiocarpal arthroscopy is performed to assess the articular disk and confirm foveal ligament tear of the TFCC. Limited intra-articular debridements were performed as indicated. No patients had a central tear or peripheral tear of the articular disk from the dorsal or ulnar wrist capsule.

Next, a previously described^{12,19,21} volar approach to the TFCC is performed through a longitudinal incision extending obliquely at the distal wrist crease along the ulnar aspect of the flexor carpi ulnaris tendon (FCU). Careful blunt dissection is carried down to the FCU, which is identified and dissected free. The ulnar nerve and the ulnar artery are both identified and protected just radial to the FCU. The dorsal cutaneous branch of the ulnar nerve is identified proximally and carefully protected. A release of Guyon's canal at the base of the palm is performed, liberating the fascial fibers overlying the ulnar nerve and artery, to allow for better mobilization of the ulnar nerve. Once free, the ulnar nerve is then carefully protected with gentle radial retraction.

The underlying pronator quadratus is identified, and at its distal aspect, the DRUJ and the submeniscal aspect of the ulnocarpal joint are exposed through a transverse submeniscal arthrotomy just proximal to the TFCC. The ulnar fovea is identified, and TFCC foveal ligament insertion is repaired using a single interrupted suture anchor (2-0 Mini-Mitek, DePuy Synthes, Warsaw, IN), and the anchor position is confirmed under fluoroscopic guidance. The suture is used to repair and resecure the remaining portion of the ligamentous foveal insertion of the TFCC back down to the fovea of the distal ulna and in the area of the prestyloid recess. In all cases, there were some residual foveal ligaments present to capture with suture. The volar capsule of the DRUJ and the released portions of the volar distal radioulnar ligament are imbricated with interrupted 3-0 Vicryl suture to further augment the tightening and stability of this repair.

Next, with the wrist in a neutral position, we placed two 0.062-inch K-wires just proximal to the DRUJ percutaneously from the ulna into the radius to eliminate forearm rotation and protect the ligament repair (►Fig. 2). The pins are cut short beneath the skin but are left slightly prominent at the ulnar aspect of the ulna and at the radial aspect of the radius in order to facilitate removal, if they break during postoperative recovery. The patient is placed into a sugar tong plaster splint in neutral position. At the 2-week postoperative visit, they are transitioned to a Munster-style long arm cast to immobilize forearm rotation. At 6 weeks, we transitioned patients to a wrist brace until pin removal in the operating room approximately after 7 to 8 weeks of the index procedure. After pin removal, a soft dressing is applied for approximately 5 days, and then patients are transitioned to a removable wrist brace as needed.

Statistical Analysis

A paired samples two-tailed *t*-test was used to compare pre- and postoperative findings. A *p*-value < 0.05 was considered statistically significant.



Fig. 2 Postoperative anteroposterior (AP) radiograph of suture anchor repair of the foveal ligament of the triangular fibrocartilage complex (A), and AP (B) and lateral (C) radiographs containing suture anchor repair with distal radioulnar joint pin fixation using K-wires.

Results

Mean patient age at surgery was 40.5 years (range 16.3–56.2). Average time from injury to surgery was 8.4 months (range 2.9–23.3 months). Average final follow-up was 18.9 months from injury (range 12.0–29.3 months), 10.5 months from surgery (range 3.9–18.6 months), and 8.7 months from pin removal (range 1.7–17.2 months). Average preoperative ulnar variance was 0.43 mm. At final follow-up, all patients demonstrated clinically stable DRUJ as determined by the treating surgeon's clinical exam. QuickDASH scores ($n = 5$) improved from pre to final postoperative visits, with averages of 55.0 (range 25.0–100.0) and 20.5 (range 4.5–34.1), respectively. Pain scores diminished ($p < 0.05$) from pre to final postoperative visits, with averages of 6.8 (range 4.0–9.0) improving to a mean of 0.70 (range 0.0–2.0), respectively. On this Likert graded scale for pain, all patient's pain scores improved.

Average postoperative forearm rotation ($n = 9$) was 71.1 degrees in supination and 76.1 degrees in pronation (average total arc of motion 147.2 degrees, range 90–160 degrees). Average postoperative wrist motion was 68.8 degrees in flexion ($n = 8$) and 70.6 degrees in extension ($n = 8$) (average total arc of motion 139.4 degrees, range 110–160 degrees). Average postoperative radial deviation was 20.0 degrees ($n = 8$), and average postoperative ulnar deviation was 34.4 degrees ($n = 8$) (►Table 1). Four (36.4%) patients initially reported transient numbness and/or paresthesias consistent with irritation of the ulnar nerve, but this deficit resolved in all patients at final follow-up. The outcomes of the WC patients did not represent outliers on any of the measured matrices. At final follow-up, no patients developed crepitus, recurrent DRUJ instability, or required revision surgery (subsequent to pin removal). Other than pin site pain, we identified one patient with a broken pin that was found during the scheduled operation for pin removal. The patient required two incisions in order to remove both segments of the broken pin.

Discussion

Our results compare favorably with open dorsal repair of the foveal ligament. In 1991, Hermansdorfer and Kleinman first described the results following an open dorsal approach to repair peripheral TFCC tears for the treatment of chronic DRUJ instability averaging 19 months.²³ They described their foveal tear repair technique utilizing ulnar-sided drill holes, and temporary pinning of the DRUJ for 4 weeks. At an average of 23 months, of the 11 patients who underwent TFCC repairs, eight had long-term pain relief, but three reported persistent ulnar wrist pain “incompatible with normal wrist demands,” and continued DRUJ instability. Two patients underwent revision surgery (►Table 1). Compared to the contralateral unaffected side, average postoperative pronation/supination arc was reported as 99%, flexion/extension arc was 86%, and grip strength was 87%.

In 2002, Adams and Berger discussed an open approach to address chronic post-traumatic DRUJ instability with tendon graft reconstruction of the dorsal and volar DRUJ ligaments in the setting of a chronic TFCC foveal tear.^{22,24} At average final follow-up of 26.4 months, 12 of 14 patients had a stable DRUJ, reported pain relief, and were able to return to previous activities. One underwent revision surgery for persistent recurrent DRUJ instability. Average postoperative pronation/supination arc was 142 degrees, or approximately 90% of preoperative range of motion and 84% of the contralateral unaffected side (►Table 1). Grip strength improved an average of 11 kg from preoperative levels, measuring 85% of the unaffected side. Flexion/extension arc was unchanged from preoperative levels.²²

A 2019 study conducted by Gillis et al examined 95 patients who underwent dorsal approach with tendon graft reconstruction for DRUJ instability and irreparable TFCC tear using the Adams-Berger surgical technique.¹⁶ At final follow-up of 65.2 months, 90.8% of patients had a stable DRUJ and 75.9% reported mild or no pain. Average postoperative pronation/supination and flexion/extension arcs were 134.0 and 110.7 degrees, respectively. Pre and postoperative grip

Table 1 Comparison of postoperative results for common TFCC repair techniques

	Current study	Moritomo (2015)	Gillis et al (2019)	Adams and Berger (2002)	Hermansdorfer and Kleinman (1991)
Number of patients (n)	9	21	95	14	11
Mean follow-up (range)	10.5 mo (4–19 mo)	26 mo (6–65 mo)	65.2 mo (28–190 mo)	26.4 mo (12–48 mo)	23 mo (8–53 mo)
Moderate-severe persistent pain	11.1%	4.8%	24.1%	14.3%	27.3%
Recurrent DRUJ instability	0.0%	19.0%	8.4%	14.3%	27.3%
Revision surgeries	0.0%	0.0%	12.6%	7.1%	18.2%
Pronation/supination arc	147.2 degrees	156 degrees	134.0 degrees	142 degrees	–
Wrist flexion/extension arc	138.4 degrees	160 degrees	110.7 degrees	–	–
Radial deviation	20.0 degrees	–	19.8 degrees	–	–
Ulnar deviation	34.4 degrees	–	28.6 degrees	–	–

Abbreviations: DRUJ, distal radioulnar joint; TFCC, triangular fibrocartilage complex.

strengths were 21.7 and 24.2 kg, respectively. The study also showed improvements in Mayo Modified Wrist Score (MMWS), with a score of 59.6 preoperatively and 68.9 postoperatively. Twelve (12.6%) patients underwent revision surgery for continued DRUJ instability at an average of 13.3 months (►Table 1). At final follow-up, 42.6% reported being able to return to their normal job, 29.8% were able to work in a restricted capacity, and 18.1% were unable to work due to wrist pain and/or DRUJ instability. Complications included transient neuropraxia of the dorsal cutaneous branch ulnar nerve (6.3%), continued symptomatic DRUJ instability (8.4%), and painful degenerative arthritis (5.2%).

Alternatively, Moritomo in 2015 reported the results of open volar repair for foveal tears of the TFCC in 21 patients.¹⁹ He reported “excellent results” in 18 patients and “good results” in the remaining three patients. At final follow-up (26 months), four patients reported mild DRUJ instability, and one reported moderate instability. Average postoperative pronation/supination and flexion/extension arcs were 156 and 160 degrees, respectively (►Table 1). Pre and postoperative grip strengths were 25 and 35 kg, respectively. The study also showed improvements in MMWS, with a score of 43 preoperatively and 92 postoperatively. Ten patients experienced transient irritation of the cutaneous branch of the ulnar nerve. Of note, 11 of 21 patients underwent simultaneous ulnar shortening, making it difficult to assess whether or not the ulnar shortening or the palmar approach to the TFCC was responsible for symptom resolution.

Based on Moritomo's results, we utilized a volar approach for repairing chronic TFCC foveal tears, with the addition of temporary pinning of the DRUJ for 8 weeks postoperatively. Each patient demonstrated dynamic instability intraoperatively, and all patients were confirmed to be stable by the treating surgeon on piano key test after suture anchor repair (prior to pinning) and at final follow-up (after pin removal). While pinning requires a secondary procedure, it was utilized to eliminate forearm rotation and protect the ligament repair. The pins were cut short beneath the skin, and zero patients experienced pin infections. Just one patient experienced pin breakage, which was identified during the scheduled second surgery for pin removal 8 weeks postoperatively. Additionally, we performed a release of Guyon's canal, liberating the fascial fibers overlying the ulnar nerve and artery, avoiding a traction palsy of the ulnar nerve. Due to the fact that patients with positive ulnar variance were excluded, none of our patients underwent ulnar shortening. For patients with significant preoperative ulnar positive variance and signs of DRUJ instability, the senior author's (S.D. D.) preferred initial treatment would be to perform an ulnar shortening osteotomy, as shortening can cause tension in the DRUJ ligaments and improve stability.

Satisfactory functional results were achieved in all patients. At the final follow-up, no patients developed crepitus, recurrent DRUJ instability, or required revision surgery. No patients experienced pain or other symptoms as a result of ulnocarpal abutment postoperatively. All patients achieved full or near-full pronation and supination. As previously mentioned, the following four patients were included: two WC patients, one case of acute-on-chronic

DRUJ instability, and one who presented for a second opinion after experiencing failure with a dorsal surgical approach. Our results further strengthen the argument for a volar approach with DRUJ pinning in patients with foveal tears of the TFCC and chronic DRUJ instability.

The present study has several limitations, including its retrospective nature and small sample size. The study was conducted without a control group or comparison to other methods performed. All surgeries were performed by a single surgeon, and functional outcomes may be influenced by surgeon-specific factors. The presence or absence of DRUJ stability was determined by the treating surgeon's clinical exam, which may be subject to examiner bias. We did not measure grip strength or make comparisons to the unaffected wrist. Beighton ligamentous laxity scores have not been recorded, not only in our study, but also in the studies to which we have contrasted our results. Ligamentous laxity can play a considerable role in the maintenance of stability after ligament repair and/or reconstruction. In our experience, patient's symptoms and pain scores continue to improve, although it is possible that ligament repairs may be found to stretch over time with longer follow-up. It would be useful to follow these patients over time to study functional outcomes over a longer period.

Conclusion

In conclusion, an open volar approach with suture anchor repair of the foveal ligament of the TFCC and temporary DRUJ fixation leads to a clinically stable DRUJ with improved functional outcomes regarding pain, stability, and range of motion in patients with the difficult clinical challenge of delayed presentation foveal ligament tears of the TFCC with associated DRUJ instability.

Conflict of Interest

None declared.

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